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period ending Sept. 30, 1981

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"Use of MAGSAT anomaly data for crustal structure
and mineral resources in the U.S. Midcontinent"

from

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(E82-10049) USE OF MAGSAT ANOMALY DATA FOR
CRUSTAL STRUCTURE AND MINERAL RESOURCES IN
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As the processed MAGSAT anomaly data continue to be released by NASA, we are able to accelerate our satellite magnetic-anomaly analysis and interpretation. We received our first profile (track) data for the U.S. Midcontinent study area on March 30th of this year, and the first fine-attitude-corrected profile data (i.e. the first tape of the final data set, for the first 80 days of the mission) in mid-July. A second tape arrived last month (August).

Over the past five months for which we have an anomaly data set, we have been engaged in:

(a) examining the magnetic-field profiles on individual tracks on the tapes provided, to identify "bad" (non-terrestrially-based) data points or profiles. Data problems can include individual spikes of anomalous data, or processing/geomagnetic transient effects on a particular pass that raise or lower the effective "zero level" of a profile. The latter leads to striping of the anomaly map along the azimuth of the satellite tracks.

Figure 1(a) shows an example of a pass (no. 85) over the U.S. Midcontinent, from 20-60° N. latitude. The individual erroneous data spikes have "anomaly" magnitudes up to 57,000 gammas (nT), with the true anomaly being indistinguishable by comparison. When these spikes are removed, as seen in Figure 1(b), the proper anomaly field is seen. It has a total amplitude of about 24 gammas.*

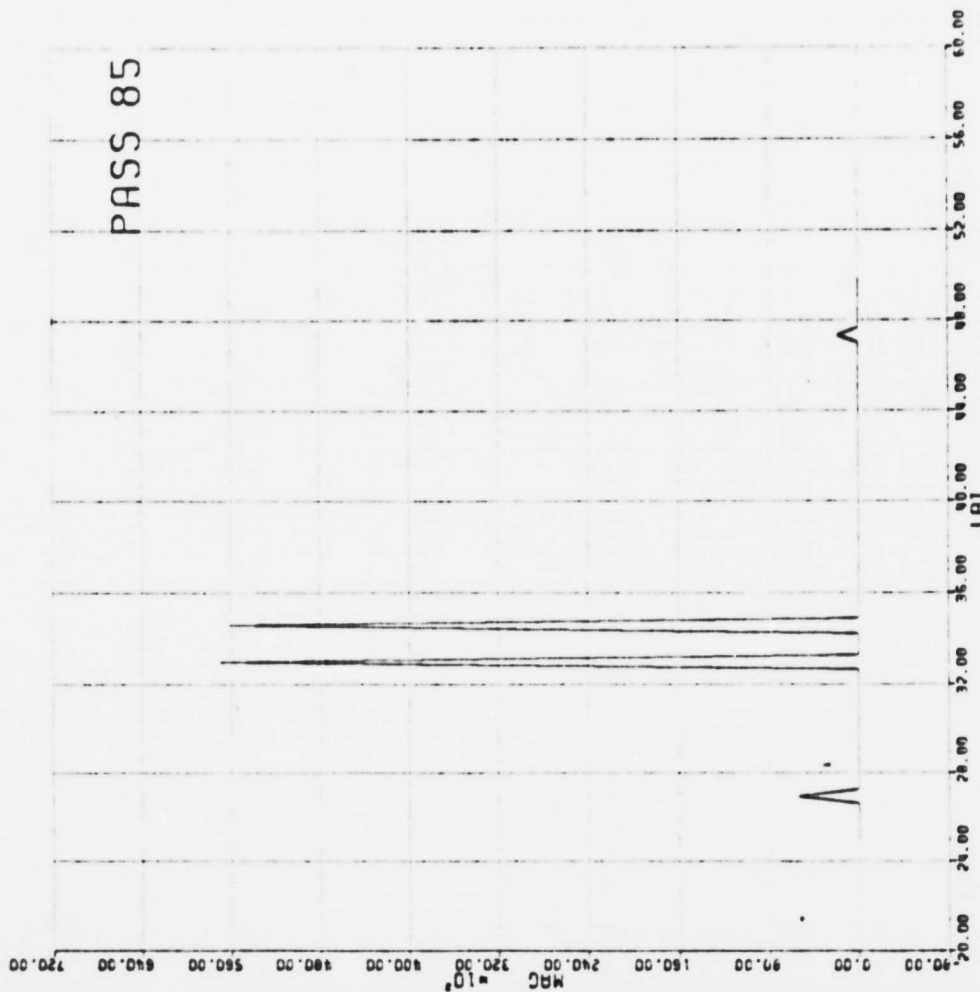
We are developing automated schemes to remove such "bad" data, as by extreme deviation from some running mean value.

(b) comparing anomaly profiles for the same satellite track but at different times (different passes), for nearby parallel tracks, and for tracks that cross. The interest is in assessing the data character and how to achieve the best data product--a magnetic anomaly map. For each data point there is a prism containing data varying with x, y, z (altitude), and t (time); e.g. 1° blocks with data averaged to a 400-km altitude. We have been doing weighted-averaging of data according to its distance from the center of the blocks and from the altitude datum-level.

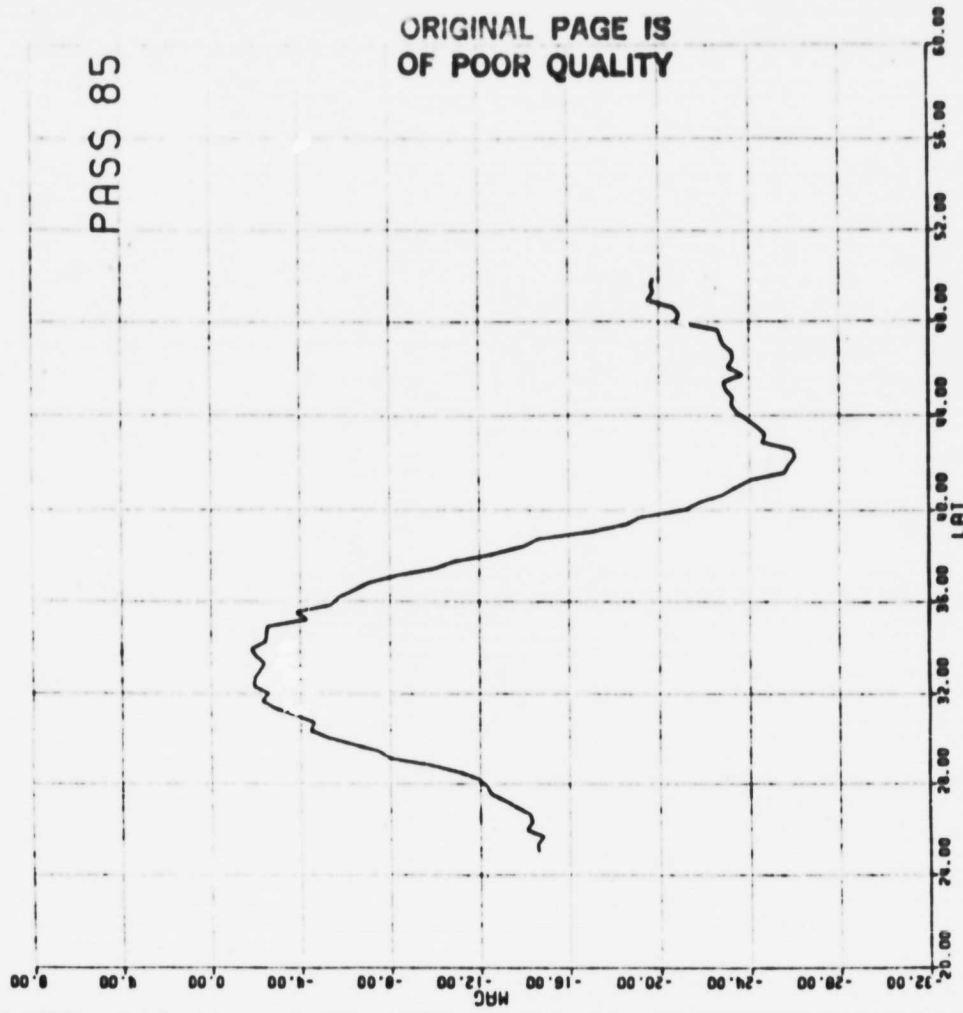
* these and subsequent anomaly profiles are the decimated investigator-tape data, so data points are about 36 km apart

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

Magnetic-field
Magnitude (gammas)



(a) original tape magnetic data (H_T), with spikes;
"anomaly" magnitude vs. latitude



(b) magnetic anomaly profile, after spikes removed

Figure 1. Track over U.S. Midcontinent (for pass 85)

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The variation is illustrated by a track over the central Midcontinent that has three nearly-coincident passes--nos. 85, 254, and 531. A typical pass orbit is shown in Figure 2, for pass 85. The latitude ranges from 25° N. (north-central Mexico) to 50° N. (north of North Dakota), and the radius for this varies from about 6765 to 6735 km. The variation of H_T (scalar field) anomaly profiles is shown in Figure 1(b) for pass 85, Figure 3(a) for pass 254, and Figure 3(b) for pass 531. On these, the large positive magnetic high is located over Oklahoma/Texas. The anomaly variation (maximum relief) decreases with altitude, as

<u>pass</u>	<u>anomaly amplitude (relief)</u>	<u>mean altitude</u>
85	24 gammas	380 km
254	20	430
531	15	520

Such data needs to be "reduced" to one data point per block (e.g. 1° or 2°). Further pro-processing includes along-track filtering to reduce the non-terrestrial short-wavelength variations (actually, short-period geomagnetic effects) as seen in Figure 1(b) for H_T of pass 85, and Fig. 4 for H_z (vertical-component) for the same pass.

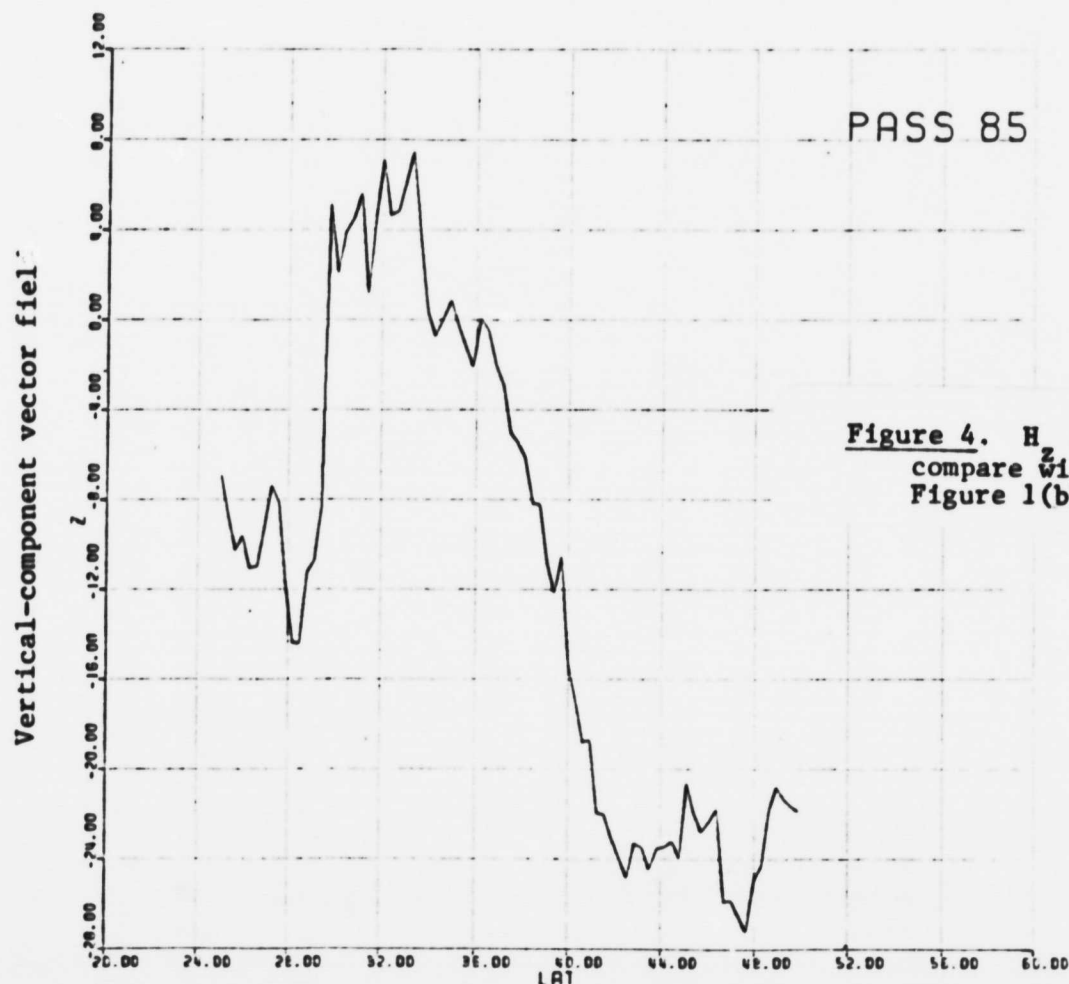


Figure 4. H_z for pass 85;
compare with H_T in
Figure 1(b)

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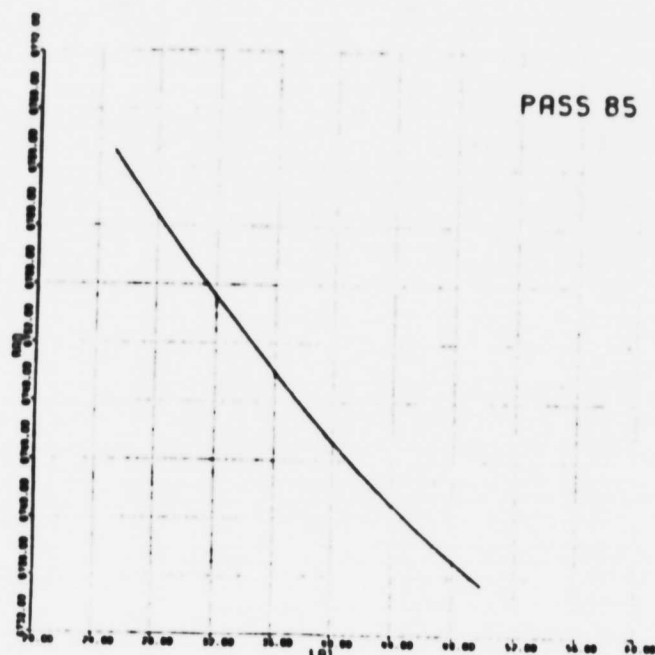


Figure 2. Orbit (radius vs. latitude) for pass 85, along common track of passes 85, 254, and 531

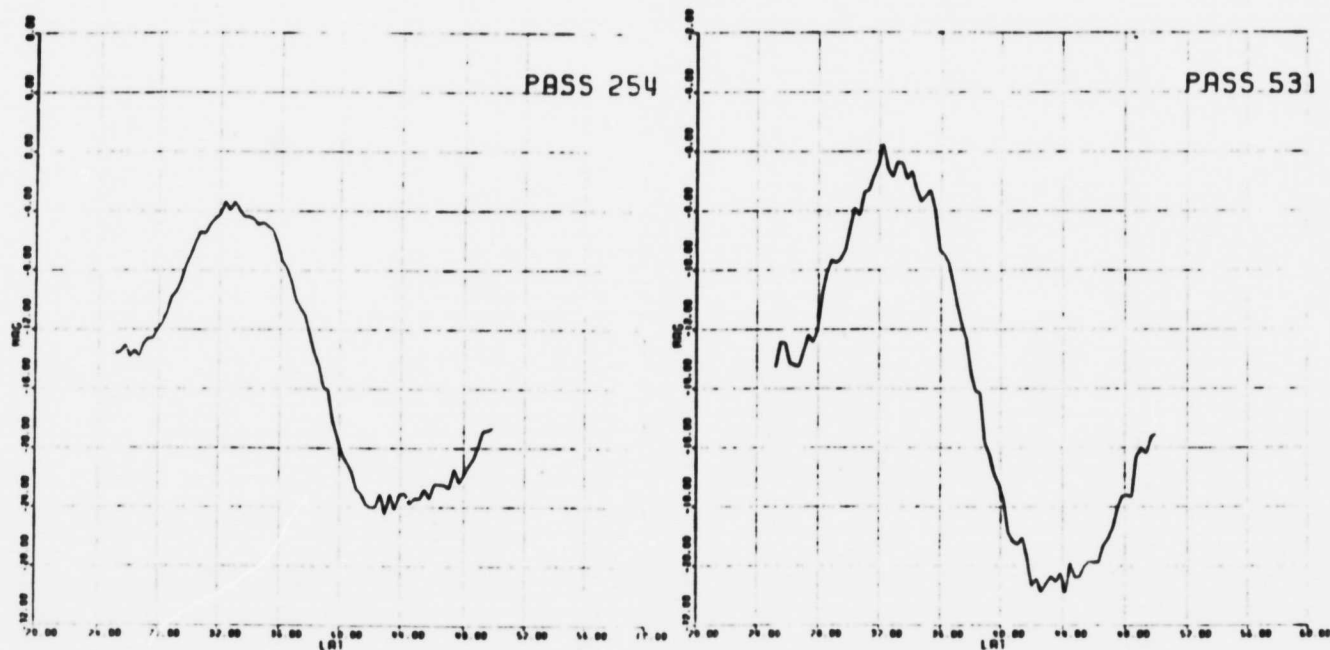


Figure 3. (a) magnetic anomaly profile, pass 254

(b) magnetic anomaly profile, pass 531

(c) plotting and contouring the selected and processed data. Figure 5(a) shows a preliminary magnetic anomaly map of H_T for the U.S. midcontinent. Data have been averaged to an altitude of 400 km on 1° blocks, with individual data weighted according to the vertical distance from the 400-km-datum and to the horizontal distance from the center of the block. This map represents about 8000 data points, after removing about 1800 as "bad"--spikes, tracks with extreme zero levels, etc. The contour interval is 2 gammas, and the map projection is Albers equal-area. The area extends from $80-105^\circ$ W. longitude, and $25-50^\circ$ N. latitude. The anomaly values range from a high (of -28, with respect to the arbitrary zero-level) in the west-east "belt" (not implying genetic continuity, however) including Oklahoma/Texas and Tennessee/Kentucky, to a low (of -26 gammas) in the northwest and south-central. The last feature seems to represent the Mississippi embayment/aulacogen.

At these latitudes (which for this part of the globe are even higher as "magnetic latitudes" because of the placement of the geomagnetic pole) the maps for H_T and H_Z are similar, whereas H_x and H_y are more irregular. There is some apparent striping of anomalies paralleling the azimuth of satellite tracks, due to incomplete equalization of zero-levels for multiple passes. To reduce this effect, one can apply a high-pass wavelength filter (low-pass wavenumber filter).^{*} Figure 5(b) shows the anomaly map treated with a 4° high-pass filter (i.e. passing wavelengths greater than about 400 km). Again, the anomaly field ranges from highs in the lower west and east, through a smaller high extending to the northeast (Wisconsin/Lake Michigan) to the lows in the northwest and extreme south. The total anomaly range is about 24 gammas in the region.

This preliminary map, based on the portion of the data received to date, is similar in general morphology to NASA's Magsat global scalar anomaly map (Langel, GSFC) of March 1981. Our map has some differences (e.g. placement of anomaly peaks, maximum gradients, etc.), and more detail which we hope is relatable to crustal properties, because of our use of: i) more data selection, and analysis and comparison of individual tracks

ii) finer averaging, on 1° blocks instead of 2° blocks.

^{*} we should note the reservation that for our purposes--interpreting crustal geologic structure and composition--we want to do as little high-pass filtering as possible, so as to retain the short-wavelength features associated with crustal sources.

ORIGINAL PAGE
COLOR PHOTOGRAPH

WIGSAT

Amplitude of the Magnetic
Anomaly is 0.5 T (500
Gauss) in 100 km. Contour
Interval is 0.1 T (100 G)
4.0 km. Contour Interval
0.1 T (100 G)

100 90

100

90

45

35

90

100

Figure 5(b) Map filtered with a 4°
high-pass wavelength filter.

WIGSAT

Amplitude of the Magnetic
Anomaly is 0.5 T (500
Gauss) in 100 km. Contour
Interval is 0.1 T (100 G)
4.0 km. Contour Interval
0.1 T (100 G)

100 90

100

90

45

35

90

100

Figure 5(a) Preliminary satellite magnetic
anomaly map (H_T) of U.S. midcontinent. Data
at 400 km, on 10 blocks.
By R. Black, 1981



INTERVAL
4

(d) beginning to interpret the satellite magnetic anomalies in terms of crustal character. One might initially expect magnetic anomaly highs to correlate with thicker crust and/or mafic crustal provinces and/or regions of lower geothermal gradient (deeper Curie-temperature isotherm). To illustrate the correlation of different geological and geophysical data sets,

i) Figure 6 shows a map of crustal thickness for North America, as determined from seismic data. In the midcontinent region, the zone of thicker crust (i.e. thicker than 45 km) runs in a belt from Okla/Texas to Tennessee. This is the same as for the magnetic anomaly highs on the satellite magnetic map. From recent work and not reflected on this map, the crust is apparently thinned on a north-south zone from the New Madrid graben down the Mississippi River embayment/rift, and there is a similar "breach" (magnetic low) in the magnetic anomaly map. The major anomaly highs over Oklahoma and Tennessee are believed to have different crustal origins, in terms of the depth and character of the respective causative sources.

ii) Figure 7 is a recent map of Precambrian-age geologic provinces for the basement rock in the Midcontinent, based on petrology and radiometric age dates (adapted from Van Schmus and Bickford, 1981). This thus represents upper crustal geologic composition, for rocks originating over 1 billion years ago. There seems to be a general correlation of the "granite/rhyolite" terrain ($1.4-1.5 \times 10^9$ years old) with the magnetic anomaly high (see Figure 5b) that trends from Oklahoma up to the northeast to Lake Michigan. This correlation of magnetics with crustal petrology may have a larger tectonic implication. One would not expect magnetic highs to be associated with granite/rhyolite directly, since those rock types are acidic/non-mafic and typically less magnetic. We are thus investigating the geological plausibility of there being an ultramafic lower crust along this zone as a consequence of a continental collision/subduction which helped form the midcontinent craton in Precambrian time.

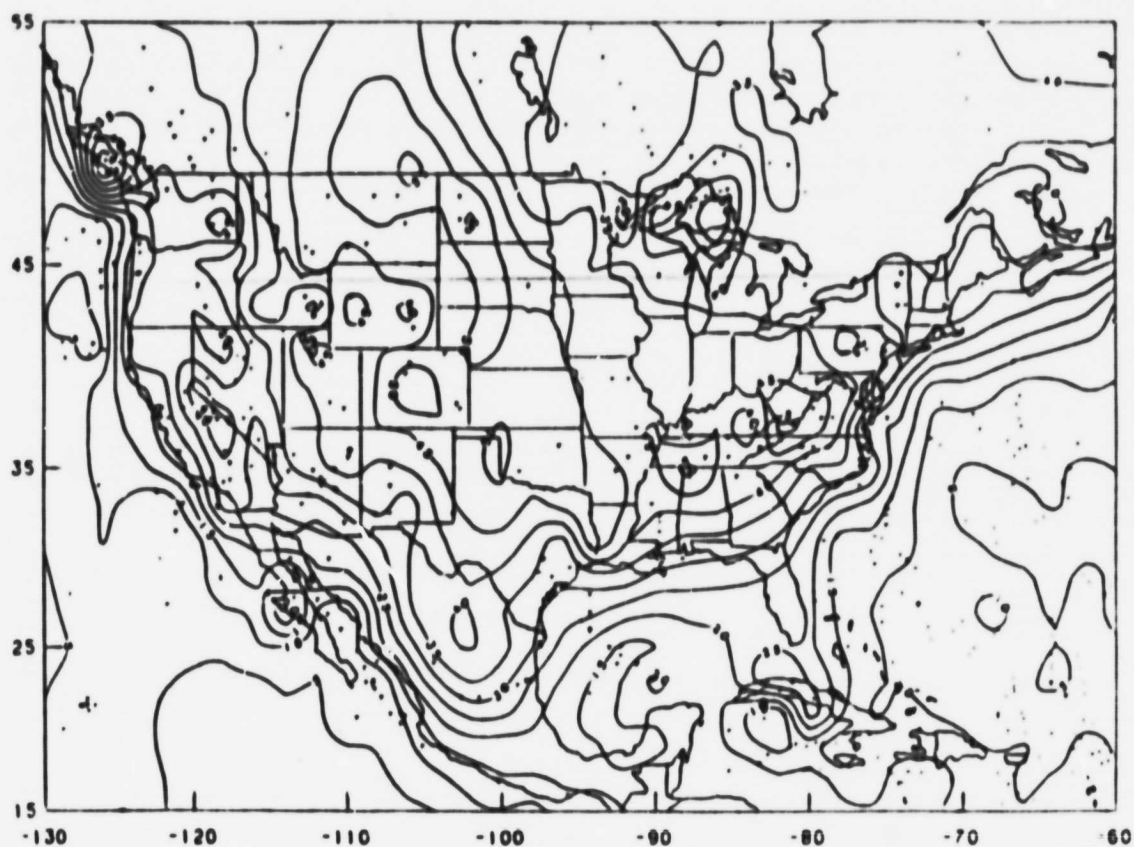


Figure 6. Crustal thickness of North America, in km. (from Soller et al, Phoenix Corp., 1981)

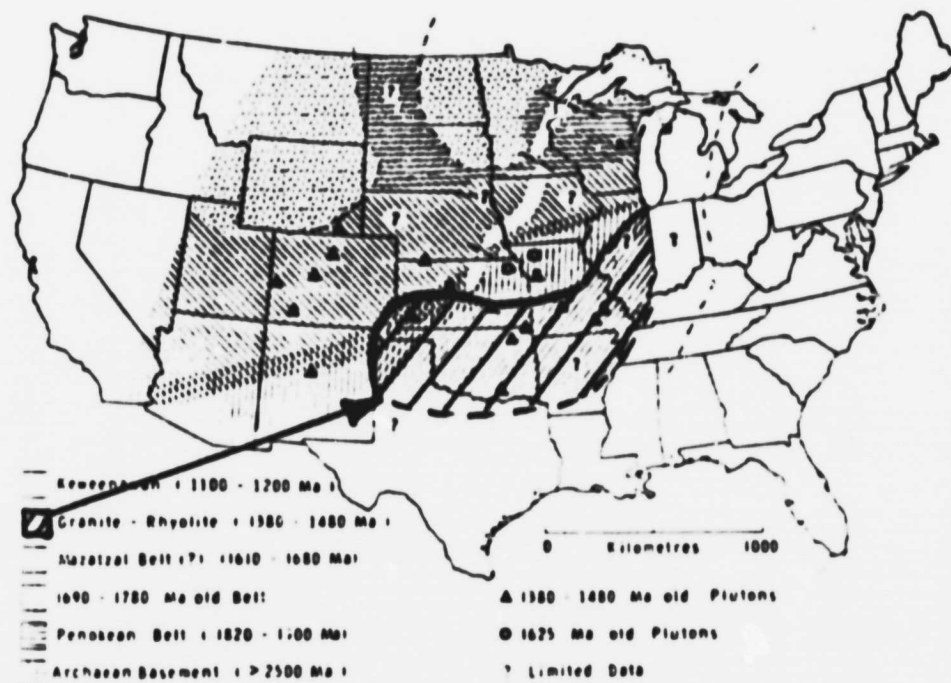


Figure 7. Precambrian-age basement provinces in U.S. mid-continent. From Van Schmus & Bickford, 1981)

Publications

The Magsat investigators had a particularly interesting and useful exchange and presentation of interim results at the NASA-sponsored meeting in Edinburgh, late July 1981. This Principal Investigator attended, and then presented a companion paper at the Assembly of the Internat. Assoc. of Geomagnetism & Aeron., Edinburgh, in early August. This was:

"Analysis and use of Magsat satellite magnetic data to help interpret crustal character of U.S. central Midcontinent"

by R. A. Black and R. S. Carmichael

A similar paper was then presented at the Internat. Basement Tectonics Conference in Oslo, in August, to a different audience whose prime interests lay in interpretation of crustal geology:

"Use of Magsat data to interpret crustal geology, structure, and geophysical properties of the U.S. midcontinent"

by R. S. Carmichael, R. A. Black, and R. A. Hoppin

Other recent related work by members of our project includes:

"Geophysical interpretation of the geology of the central segment of the Midcontinent geophysical anomaly"

by R. Anderson and R. A. Black, Ann. Midwest Mtg. of Amer. Geophysical Union, Minneapolis, September 1981

"New Bouguer gravity map of Iowa"

by R. Anderson, North-Central Ann. Mtg of Geological Soc. of Amer., Ames, May 1981

Funds Expended (July - September, 1981)

Previously spent and committed (Dec. 1980 - June 1981)	\$	8,178.79
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Committed in this quarter:

Supplies, materials, xeroxing, postage, slides for NASA and other talks	184.50
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Iowa Geological Survey subcontract for computer data processing and analysis, \$2667 (included in funds committed previously)	
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Research Assistantship, graduate student	999.
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Investigators' summer salaries	3,670.50
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Staff benefits (to Univ.; for June-Sept.)	1,114.09
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Special travel allotment (add-on funds from NASA for trip to NASA meeting and Magsat conferences in Europe, July/Aug. 1981)	1,500.
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Overhead (to Univ.; for June-Sept.)	2,962.66
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Total to date	18,609.54
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